Revista Brasileira de Zootecnia
Brazilian Journal of Animal Science
© 2017 Sociedade Brasileira de Zootecnia
ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., 46(1):80-84, 2017

Short Communication

Sugarcane bagasse as exclusive roughage for dairy heifers

Jonas Gomes Inácio[1*], Marcelo de Andrade Ferreira[1], Randerson Cavalcante Silva[1], Janaina de Lima Silva[2], Júlio César Vieira de Oliveira[3], Djalma Cordeiro dos Santos[3], Luciana Felizardo Pereira Soares[1], José Maurício de Souza Campos[4]

[1] *Universidade Federal Rural de Pernambuco, Departamento de Zootecnia, Recife, PE, Brazil.*
[2] *Universidade Federal do Oeste da Bahia, Barra, BA, Brazil.*
[3] *Instituto Agronômico de Pernambuco, Arcoverde, PE, Brazil.*
[4] *Universidade Federal de Viçosa, Viçosa, MG, Brazil.*

ABSTRACT - The objective of this study was to evaluate the effect of different concentrate levels (40, 50, 60, and 70% on dry matter basis) on intake, digestibility of nutrients, and performance of heifers fed sugarcane bagasse as exclusive roughage. Twenty Girolando heifers, with an average body weight of 198±25.6 kg were assigned to a completely randomized design, established according to body weight. The intake of dry matter (5.12 to 7.73 kg d^{-1}), organic matter (4.72 to 7.32 kg d^{-1}), crude protein (0.71 to 1.05 kg d^{-1}), and digestible organic matter (3.09 to 4.77 kg d^{-1}) linearly increased with the inclusion of concentrate in the diets. The final weight (238 to 299 kg d^{-1}), body weight gain (0.50 to 1.20 kg d^{-1}), and total weight gain (35.2 to 83.6 kg d^{-1}) linearly increased with the concentrate levels. Considering the occurrence of the first calving at 24 months, a 50:50 ratio of sugarcane bagasse to concentrate seems to be the most appropriate for crossbred heifers.

Key Words: agro-industrial waste, digestibility, intake, morphometry, rearing, semiarid

Introduction

The establishment of an efficient rearing system, especially for females, has been a major challenge for most dairy farmers. Poor feed management has led to late age at first calving, which contributes to a reduction in the number of dairy cows, consequently reducing herd productivity and animal lifespan.

In Brazil, as in most of the world, pastures are the best practical way to feed animals. However, forage availability and quality decreases during the dry seasons, worsening during prolonged droughts, which is directly reflected in production rates. In semi-arid regions, the situation is more critical due to low forage availability during most of the year, justifying the animal maintenance in feedlots (Ferreira et al., 2011).

It is important to highlight that Brazil is the major sugarcane producer in the world and for every tonne of processed sugarcane in the ethanol industries, about 0.3 t of bagasse is generated (Hofsetz and Silva, 2012). One advantage of sugarcane bagasse is the high availability exactly during fodder shortage, besides being cheaper than other conventional roughages. So, the sugarcane bagasse has become extremely important in the semiarid regions, due to the severe droughts in the last years, and is the unique source of roughage feed available for ruminants.

In the Brazilian Northeast, this byproduct is widely used as roughage due to the proximity to sugar-ethanol industries and is usually used for beef cattle (Rabelo et al., 2008; Barros et al., 2010). Leme et al. (2003) reported that the sugarcane bagasse can be used as exclusive source of roughage for beef cattle. However, Bulle et al. (2002) found that 15% of sugarcane bagasse provides higher body weight gain in crossbred bulls. These contradictory results are related to the high low-digestible fiber content of sugarcane bagasse, promoting greater retention in the digestive tract and restrictions in the intake (Voltolini et al., 2008).

For these reasons and because most studies have been conducted with finishing beef cattle aimed at maximum performance, there is a need for studies with dairy heifers, since the objectives are different. According to Albino et al. (2015), several authors have reported a greater rate of gain

Received: May 2, 2016
Accepted: August 21, 2016
***Corresponding author:** jonaseafc@yahoo.com.br
http://dx.doi.org/10.1590/S1806-92902017000100012

How to cite: Inácio, J. G.; Ferreira, M. A.; Silva, R. C.; Silva, J. L.; Oliveira, J. C. V.; Santos, D. C.; Soares, L. F. P. and Campos, J. M. S. 2017. Sugarcane bagasse as exclusive roughage for dairy heifers. Revista Brasileira de Zootecnia 46(1):80-84.

in the rearing phase with impaired mammary development; however, other authors have suggested that the main influence on the accumulation of fat in the mammary gland is the energy to protein ratio consumed by the animal and not specifically the energy intake. In this case, for Holstein heifers gaining more than 1 kg d^{-1}, it is not recommended (Albino et al., 2015); however, for crossbred heifers, the maximum gain has not yet been established. Thus, we hypothesized that the establishment of a proper roughage to concentrate ratio, using sugarcane bagasse as exclusive roughage for dairy heifers in the rearing phase could promote the anticipation of the first calving.

Therefore, the objective of this study was to evaluate the effect of different concentrate levels of sugarcane bagasse as exclusive roughage in diets for dairy heifers on intake, nutrient digestibility, and performance.

Material and Methods

This study was carried out in Arcoverde, Pernambuco, Brazil. The management and care of animals were performed in accordance with the guidelines and recommendations of the Committee of Ethics on Animal Studies (Case no. 033/2014), Recife, Brazil.

Twenty Girolando (5/8 Holstein-Gir) heifers with an average initial weight of 198±25.6 kg were maintained in a feedlot. At the beginning of the trial, the heifers received treatment against endoparasites and ectoparasites and vitamin supplements (A, D, and E). The experiment lasted for 114 days, of which 30 days were for adaptation to the diets and installations and 84 days were for data and sample collection and performance evaluation of the heifers.

The diets consisted of four different levels of concentrate (40, 50, 60, and 70% on dry matter (DM) basis) and sugarcane bagasse as exclusive roughage (Tables 1 and 2). The diets were formulated to be isonitrogenous, considering the composition of the ingredients (Table 1), according to the NRC (2001) for the protein requirements for a weight gain of 700 g d^{-1}. The animals were fed twice daily (at 08.00 and 16.00 h). The amount of feed supplied was corrected daily to generate 10% of orts. Feeds and orts were weighed daily throughout the experimental period to calculate the voluntary intake. Composite samples of feeds supplied and orts were formed weekly and stored at –20 ºC in airtight plastic bags.

Spot fecal samples were collected directly from the rectum of the animals on day 30 of the experimental period, for five consecutive days, at different times after feeding (08.00, 10.00, 12.00, 14.00, and 16.00 h). To estimate the apparent digestibility coefficients, the indigestible neutral detergent fiber (iNDF) was used as an internal marker, obtained after 288 h of ruminal incubation time (Valente et al., 2011).

Samples of feeds, orts, and feces were dried in a forced-ventilation oven at 55 ºC for 72 h and ground in a Wiley mill with a 1-mm screen to determine the chemical composition; a 2-mm screen was used in samples for *in situ* rumen incubation.

Table 2 - Proportion of ingredients and chemical composition of the experimental diets

Item	Concentrate level (%)			
	40	50	60	70
Ingredient (g kg^{-1})				
Sugarcane bagasse	595	494	394	294
Corn	201	305	408	511
Soybean meal	179	178	178	178
Urea/ammonium sulphate[1]	11.1	8.00	5.00	2.10
Salt	5.10	5.10	5.00	5.00
Mineral[2]	10.1	10.1	10.1	10.1
Diet composition (g kg^{-1} of DM)				
Dry matter (g kg^{-1} as fed)	615	649	687	728
Organic matter	923	931	939	947
Crude protein	139	138	137	136
Ether extract	14.9	19.1	23.3	27.4
NDFap	515	449	383	318
Acid detergent fiber	397	341	285	230
Non-fibrous carbohydrates	248	319	392	463

NDFap - neutral detergent fiber corrected for ash and protein.
[1] Nine parts of urea and one part of ammonium sulphate.
[2] Calcium, 220 g kg^{-1}; phosphorus, 60 g kg^{-1}; sodium, 70 g kg^{-1}; magnesium, 20 g kg^{-1}; potassium, 35 g kg^{-1}; copper, 700 mg kg^{-1}; chrome, 10 mg kg^{-1}; iron, 700 mg kg^{-1}; cobalt, 15 mg kg^{-1}; manganese, 1600 mg kg^{-1}; zinc, 2500 mg kg^{-1}; iodine, 40.0 mg kg^{-1}; selenium, 19 mg kg^{-1}; sulphur, 20 g kg^{-1}; fluorine, 600 mg kg^{-1}.

Table 1 - Chemical composition of ingredients used in the experimental diets (g kg^{-1} DM)

Item	Sugarcane bagasse	Corn	Soybean meal	Salt	Mineral	Urea/ammonium sulfate
Dry matter (g kg^{-1})	503	883	934	-	-	-
Organic matter	938	988	937	-	-	-
Crude protein	20.0	87.2	449	-	-	265
Ether extract	5.8	46.0	12.4	-	-	-
NDFap	784	123	138	-	-	-
Acid detergent fiber	639	43.9	69.3	-	-	-
Non-fibrous carbohydrates	721	765	286	-	-	-

DM - dry matter; NDFap - neutral detergent fiber corrected for ash and protein.

Dry matter, organic matter (OM), and crude protein (CP) analyses were performed according to the Association of Official Analytical Chemists (AOAC, 1990), method number 934.01 for DM, 930.05 for OM, and 981.10 for CP. Ether extract (EE) was analyzed by Soxhlet extraction with petroleum ether, according to the AOAC (1990), method number 920.39. The concentration of neutral detergent fiber (NDF) was assayed with a heat-stable amylase and corrected for ash based on the procedures described by Mertens (2002), except that the samples were placed in polyethylene pots with 100 mL of neutral detergent and autoclaved (Senger et al., 2008). For determination of acid detergent fiber (ADF), 100 mL of acid detergent were added (Van Soest and Robertson, 1985). Neutral detergent insoluble nitrogen and acid detergent insoluble nitrogen (Licitra et al., 1996) were measured using the Kjeldahl method. Non-fribrous carbohydrates (NFC) were calculated as follows, according to Hall (2000): NFC (g kg^{-1}) = 1000 − [(CP – urea derived CP + urea) + NDFap + EE + ash], in which: NDFap = neutral detergent fiber corrected for ash and protein.

The body weight (BW) of each heifer was measured at the start, every 28 days, and at the end of the experiment, after a fasting period of 16 h. Body weight gain (BWG) was estimated considering the BW at the start and the end of the experiment.

The heifers were distributed into a completely randomized design. The studied variables were analyzed by the variance and regression analyses using the PROC MIXED procedure of SAS (Statistical Analysis System, version 9.1), adopting 0.05 as the critical level of probability for type I error, according to the following model:

$$Y_{ij} = \mu + T_i + \beta(X_{ij} - X) + e_{ij},$$

in which Y_{ij} = observed value of the dependent variable; μ = overall mean; T_i = effect of treatment i (i = 1 to 4); $\beta(X_{ij} - X)$ = covariate effect (initial weight); and e_{ij} = experimental error.

Results

Except for NDFap intake, which was not changed (P>0.05) with increased concentrate levels in the diets, there was a linear increase (P<0.01) in DM, OM, CP, and digestible organic matter (DOM) intake, and a linear decrease (P<0.01) of NDFap in g kg^{-1} of BW (Table 3). Apparent digestibility of DM and OM showed quadratic behavior (P<0.05), with maximum values of 654 and 689 g kg^{-1} in 57.9 and 55.7% concentrate inclusion levels, respectively (Table 3). For apparent digestibility of CP, there was a linear decrease (P<0.01) with an increase in concentrate levels, while apparent digestibility of NDFap was not influenced (P>0.05).

Final weight, average daily gain, and total weight gain increased linearly (P<0.01) with increase in concentrate in the diets (Table 4). Consequently, there was a linear decrease (P<0.01) in feed conversion.

Table 3 - Nutrient intake and apparent digestibility in heifers fed different concentrate levels in diets containing sugarcane bagasse as exclusive roughage

Item	Concentrate level (%)				SEM	P-value		
	40	50	60	70		L	Q	COV
Daily intake (kg d^{-1})								
Dry matter[1]	5.12	5.75	6.38	7.73	0.38	<0.0001	0.355	0.316
Dry matter (g kg^{-1} of BW)	24.2	25.4	27.6	32.2	0.09	<0.0000	0.061	0.258
Organic matter[2]	4.72	5.35	5.99	7.32	0.35	<0.0001	0.337	0.489
Crude protein[3]	0.71	0.79	0.87	1.05	0.05	<0.0002	0.377	0.473
NDFap	2.66	2.58	2.44	2.46	0.15	0.3300	0.825	0.233
NDFap (g kg^{-1} of BW)	12.3	11.4	10.7	10.2	0.40	<0.0004	0.312	0.123
Digestible organic matter[4]	3.09	3.57	4.16	4.77	0.23	<0.0001	0.793	0.322
Digestibility (g kg^{-1})								
Dry matter[5]	612	629	661	626	1.34	0.2246	0.041	0.412
Organic matter[6]	654	668	696	653	1.36	0.6753	0.047	0.521
Crude protein[7]	825	798	799	741	1.27	0.0004	0.247	0.478
NDFap	459	429	428	431	1.96	0.1871	0.260	0.584

BW - body weight; NDFap - neutral detergent fiber corrected for ash and protein; SEM - standard error of the mean; L - linear effect; Q - quadratic effect; COV - covariate.
[1] $\hat{Y} = 1.592 + 0.084*X$.
[2] $\hat{Y} = 1.203 + 0.084*X$.
[3] $\hat{Y} = 0.25 + 0.011*X$.
[4] $\hat{Y} = 0.801 + 0.056*X$.
[5] $\hat{Y} = 214.3 + 15.04*X - 0.13*X^2$.
[6] $\hat{Y} = 240.7 + 15.92*X - 0.142*X^2$.
[7] $\hat{Y} = 928.8 - 2.51*X$.

Table 4 - Performance of heifers fed different concentrate levels in diets containing sugarcane bagasse as exclusive roughage

Item	Concentrate level (%)				SEM	P-value		
	40	50	60	70		L	Q	COV
Initial body weight (kg)	196	202	197	199	12.43	-	-	-
Final body weight[1] (kg)	238	261	273	299	14.21	<0.0183	0.895	0.100
Body weight gain[2] (kg d^{-1})	0.50	0.70	0.90	1.20	0.05	<0.0000	0.872	0.091
Total weight gain[3] (kg)	35.2	50.0	67.8	83.6	3.41	<0.0000	0.885	0.091
Feed conversion[4] (kg DM kg^{-1} BWG)	10.3	8.00	6.60	6.50	0.39	<0.0001	0.015	0.286

DM - dry matter; BWG - body weight gain; SEM - standard error of the mean; L - linear effect; Q - quadratic effect; COV - covariate.
[1] $\hat{Y} = 160.5 + 1.97*X$.
[2] $\hat{Y} = -0.44 + 0.023*X$.
[3] $\hat{Y} = -30.5 + 1.63*X$.
[4] $\hat{Y} = 14.89 - 0.128*X$.

Discussion

With the inclusion of 70% concentrate in the diet, higher DM, OM, CP, and DOM intakes were observed, which could be explained by a higher concentration of fast ruminal fermentation carbohydrates (NFC) and lower fiber content (NDF). According to the NRC (1996), when animals are fed high fiber contents, as in the case of diets with higher sugarcane bagasse ratio, intake is controlled by physical factors, such as passage rates and rumen fill. However, when the concentrate level is increased (high energy density), intake is controlled by energy demand and metabolic factors. Although there is a decrease in NDFap content with the addition of concentrate, dry matter intake increased. Thus, fiber intake was not changed.

Despite the known influence of the amount of fiber in the diet on feed intake and ruminal fermentation, information about optimal, maximum, and minimum NDF levels for dairy heifers is scarce. It is noteworthy that in the 59.5% sugarcane bagasse diet, heifers received about 90% of fiber derived from low digestible roughage, with a greater retention time in the rumen. In the last treatment (29.4% sugarcane bagasse), fiber ratio decreased to 71%. The fiber was replaced by the fiber of the concentrate feed with higher degradation and ruminal passage.

The quadratic effect observed for DM and OM digestibilities can be explained by the increased intake of these nutrients. However, a reduction in DM and OM digestibilities was observed with concentrate inclusion above 58 and 56%, possibly due to the high content of carbohydrates, which are easily fermentable in the rumen (NFC) and have fast degradation rate, resulting in decrease of ruminal pH. Due to decrease in ruminal pH, there is a subsequent deleterious effect on cellulolytic microbiota and digestibility of some nutrients (Dijkstra et al., 2012). According to Lechner-Doll et al. (1991), passage rate in the rumen increases with particle size reduction. This partially justifies the CP digestibility reduction, due to the increase in concentrate supply associated with increase in diet passage rate, besides the lack of effects on NDFap digestibility.

The increase in total weight gain and average daily gain were related to increase in DM, CP, and DOM intake, as concentrate levels increased. Heifers receiving the 50:50 (roughage:concentrate) treatment gained 0.70 kg d^{-1}. According to Albino et al. (2015), it is not recommended for Holstein heifers to gain more than 1 kg d^{-1} in the rearing phase to avoid fat accumulation in the mammary gland; however, for crossbred heifers, the maximum gain has not yet been established. According to several authors, the average daily gain around 0.70 kg d^{-1} (Abeni et al., 2000; Shamay et al., 2005) is ideal to achieve target milk performance. This constant weight gain can be considered appropriate for Girolando heifers to enable the first calving at 24 months of age, with 450-500 kg of BW considered optimal for this breed.

According to the objective of the farmers, average gains of more than 0.80 kg d^{-1} could be achieved through the roughage to concentrate ratio using sugarcane bagasse. Average gains of 0.90 and 1.20 kg d^{-1}, recorded for heifers fed 60 and 70% concentrate level, respectively, may be considered high for crossbred animals. Knight and Sorensen (2001) verified that ADG of 0.9 kg d^{-1} promoted a decrease in the mammary parenchyma.

The search for early age at first calving is questionable and the relations of price between inputs and products should be analyzed to determine the optimum age for each rearing system. In Brazil, Moreira (2012) assessed a reduction of age at first calving from 30 to 24 months for lactating heifers and concluded that this management could increase dairy farming gross income in more than 30%, also increasing the remuneration rate by the same proportion. According to Gomes (2006), this behavior is related to the percentage of dairy cows in relation to the total herd. Therefore, proper feeding management should be maintained in the rearing phase to reduce age at first calving and increase the proportion of lactating animals, increasing the system revenue.

Conclusions

Considering the occurrence of the first calving at 24 months, a 50:50 ratio of sugarcane bagasse to concentrate seems to be the most appropriate for crossbred heifers.

Acknowledgments

To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the funding of the research project.

References

Abeni, F.; Calamari, L.; Stefanini, L. and Pirlo, G. 2000. Effects of dairy gain in pre- and postpubertal replacement dairy heifers on body condition score, body size, metabolic profile, and future milk production. Journal of Dairy Science 83:1468-1478.

Albino, R. L.; Marcondes, M. I.; Akers, R. M.; Detmann, E.; Carvalho, B. C. and Silva, T. E. 2015. Mammary gland development of dairy heifers fed diets containing increasing levels of metabolizable protein:metabolizable energy. Journal of Dairy Research 82:113-120.

AOAC - Association of Official Analytical Chemists. 1990. Official methods of analysis. 15th ed. AOAC International, Arlington, VA.

Barros, R. C.; Rocha Júnior, V. R.; Souza, A. S.; Franco, M. O.; Oliveira, T. S.; Mendes, G. A.; Pires, D. A. A.; Sales, E. C. J. and Caldeira, L. A. 2010. Economic viability of substitution of sorghum silage by sugarcane or sugarcane bagasse ammoniated with urea for cattle in feedlot. Revista Brasileira de Saúde e Produção Animal 11:555-569.

Bulle, M. L. M.; Ribeiro, F. G.; Leme, P. R.; Titto, E. A. L. and Lanna, D. P. D. 2002. Desempenho de tourinhos cruzados em dietas de alto teor de concentrado com bagaço de cana-de-açúcar com único volumoso. Revista Brasileira de Zootecnia 31:444-450.

Dijkstra, J.; Ellis, J. L.; Kebreab, A. E.; Strathe, A. B.; López, S.; France, J. and Bannink, A. 2012. Ruminal pH regulation and nutritional consequences of low pH. Animal Feed Science and Technology 172:22-33.

Ferreira, M. A.; Pessoa, R. A. S.; Silva, F. M. and Bispo, S. V. 2011. Palma forrageira e ureia na alimentação de vacas leiteiras. Universidade Federal Rural de Recife, Recife.

Gomes, S. T. 2006. Diagnóstico da pecuária leiteira do estado de Minas Gerais. FAEMG, Belo Horizonte.

Hall, M. B. 2000. Calculation of non-structural carbohydrate content of feeds that contain non-protein nitrogen. Bull. Tech. University of Florida, FL, USA.

Hofsetz, K. and Silva, M. A. 2012. Brazilian sugarcane bagasse: Energy and non-energy consumption. Biomass and Bioenergy 46:S64-S73.

Knight, C. H. and Sorensen, A. 2001. Windows in early mammary development: criticalor not? Reproduction 122:337-345.

Lechner-Doll, M.; Kaske, M. and Englehardt, J. 1991. Factors affecting the mean retention time of particles in the forestomach of ruminants and camelids. p.455-482. In: Physiological aspectsof digestion and metabolism in ruminants. Tsuda, T.; Sasaki, Y. and Kawashima, R., eds. Academic Press, San Diego.

Leme, P. R.; Silva, S. L.; Pereira, A. S. C.; Putrino, S. M.; Lanna, D. P. D. and Nogueira Filho, J. C. M. 2003. Utilização do bagaço de cana-de-açúcar em dietas com elevada proporção de concentrados para novilhos Nelore em confinamento. Revista Brasileira de Zootecnia 32:1786-1791.

Licitra, G.; Hernandez, T. M. and Van Soest, P. J. 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. Animal Feed Science and Technology 57:347-358.

Mertens, D. R. 2002. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: collaborative study. Journal of AOAC International 85:1217-1240.

Moreira, M. V. C. 2012. Custo de criação de novilhas na região da zona da mata mineira. Tese (D.Sc.). Universidade Federal de Viçosa, Viçosa, MG, Brazil.

NRC - National Research Council. 1996. Nutrient requirements of beef cattle. 7th ed. Washington, D.C.

NRC - National Research Council. 2001. Nutrient requirements of dairy cattle. 7th ed. Washington, D.C.

Rabelo, M. M. A.; Pires, A. V.; Susin, I.; Mendes, C. Q.; Oliveira Junior, R. C. and Ferreira, E. M. 2008. Digestibility of nutrients and ruminal characteristics in beef cattle fed rations containing sugarcane bagasse obtained by diffusion or conventional milling extraction method. Revista Brasileira de Zootecnia 37:1696-1703.

Senger, C. C. D.; Kozloski, G. V.; Sanchez, L. M. B.; Mesquita, F. R.; Alves, T. P. and Castagnino, D. S. 2008. Evaluation of autoclave procedures for fibre analysis in forage and concentrate feedstuffs. Animal Feed Science and Technology 146:169-174.

Shamay, A.; Werner, D.; Moallem, U.; Barash, H. and Bruckental, I. 2005. Effect of nursing management and skeletal size at weaning on puberty, skeletal growth rate, and milk production during first lactation of dairy heifers. Journal of Dairy Science 44:1460-1469.

Van Soest, P. J. and Robertson, J. B. 1985. Analysis of forages and fibrous foods. Cornell University, Ithaca.

Valente, T. N. P.; Detmann, E.; Queiroz, A. C.; Valadares Filho, S. C.; Gomes, D. I. and Figueiras, J. F. 2011. Evaluation of ruminal degradation profiles of forages using bags made from different textiles. Revista Brasileira de Zootecnia 40:666-675.

Voltolini, T. V.; Santos, F. A. P.; Martinez, J. C.; Bittar, C. M. M.; Imaizumi, H. and Cortinhas, C. S. 2008. Different metabolizable protein levels in sugar cane diets to lactating dairy cows. Brazilian Journal of Veterinary Research and Animal Science 9:309-318.